NOTES ON THE TERTIARY GEOLOGY OF THE SOUTHERN UNITED STATES.

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In the following notes the author makes no pretense at unravelling the many knotty points connected with the Tertiary geology of the southern United States; he has merely brought together such facts, old and new, and certain conclusions drawn from these facts, as may possibly serve to facilitate the inquiry into this as yet imperfectly known branch of American geological history. It is with this view of rendering the material treating of the subject more accessible to the working geologist that some of the published sections are here reproduced.

A convenient starting-point in Eocene stratigraphy is afforded by the famous bluff exposed on the Alabama River near Claiborne, Ala., and which has yielded the fossils known to geologists and paleontologists as those characteristic of the "Claiborne Group."

Section of Claiborne Bluff.—Probably the most trustworthy section of this bluff is that afforded by Tuomey ("First Biennial Report of the Geology of Alabama," 1850, p. 152), as follows:

		Feet.
g	Red sand, loam, and pebbles.	30
f	Mottled clay.	8
e	Limestone, with grains of green sand.	54
d	Ferruginous sand; numerous fossils.	
c	Whitish limestone.	62
b	Bed of clay 15 feet thick, with seam of limestone on top.	15

NOTE.—Tuomey does not give the thickness of bed "*d*," but it appears from the concurrent statements of different observers to be about 17 feet. The total height of the bluff above the Alabama River would therefore appear to be in the neighborhood of 190 feet.

The measurements and descriptions of Conrad ("Fossil Shells of the Tertiary Formations," 1833, p 32; Proceedings of the National Institution, 1841. p. 174), Hale ("Geology of South Alabama," American Journal of Science, new ser., VI, p. 354), and Lyell (Journal of the Geological Society, IV, p. 10, *et seq.*) do not differ very essentially from the data given by Tuomey. The arenaceous bed "*d*," about 80 feet above water level, has yielded the vast majority of the fossils for which the locality is famous, and is that which has been identified as the equivalent of the "Calcaire Grossier" (Upper Eocene) of France (*et conseq.*, Bruxellian of Belgium, and Bartonian of England). To what extent the deposits either below or above this bed can be correlated with the remaining deposits of the Paris or London series has not yet been determined; nor has it yet been conclusively shown what exact portion of the American Eocene formation is represented in this Claiborne exposure. Although formerly considered to be near the base of the system, there are now very strong grounds for concluding that these beds are underlaid by older Eocene strata having a thickness of at least 200 feet, and possibly even much more. The age of the limestone bed "*e*," although perhaps the character of its contained fossils does not permit absolute determination, is in all probability Jacksonian—at least in part—and will doubtless be found to correspond with a portion of the bluff exposed at St. Stephen's on the Tombigbee River, about thirty miles almost due west of Claiborne. At any rate, a portion of the white, or so-called "rotten" limestone immediately west of Claiborne has been found to contain several of the characteristic fossils of the Jackson group, and these associated with the remains of *Zeuglodon;* there is, therefore, no doubt as to the age of at least this portion of the white limestone, nor can there be any reasonable doubt as to the continuity existing between these deposits and the similar ones exposed on Claiborne bluff.

Section on Bashia Creek, Clarke Co., Ala.—Probably the section representing the oldest Eocene deposits of the State of Alabama is that exposed on Bashia Creek, Clarke Co., and detailed by Toumey in his report on the geology of the State (First Biennial report, p. 145):

1	Hard Limestone.	4 feet.
2	Marl, highly fossiliferous.	25 feet.
3	Blue sand.	Variable.
4	Lignite and clay.	6 feet.
5	Laminated clay, sand, and mud.	Thickness undetermined.
6	Lignite.	do. do.

NOTE.—Beds 5 and 6 do not properly belong to the section, but "represent beds seen on another part of the stream below the preceding" (Tuomey, *loc. cit.*, p. 146).

Beds corresponding to No. "2" of the above section are likewise exposed on Cave and Knight's branches, tributaries of Bashia Creek, and have been shown by Dr. Eugene A. Smith to underly the *base* of the "Buhrstone" proper by nearly (if not more than) 200 feet (Heilprin, "Proc. Acad. Nat. Sciences of Philadelphia," 1881, p. 369). The relations of these various beds will be best understood by a reference to the sections exposed on the Tombigbee River.

Sections on the Tombigbee River.—At Wood's Bluff, near the mouth of Bashia Creek, we have the following exposure:[1]

No.		Feet.
7	Orange sand, or stratified drift.	10–20
6	Grayish or greenish laminated clays, colored brown by iron.	10
5	Ledge of bluish or greenish sand, fossiliferous—capped by a ledge of hard nodules.	2
4	Bluish laminated clay, with few fossils.	5
3	Indurated greenish sand, full of the same shells as marl bed No. 2.	3
2	Greensand marl, quite soft, and full of shells.	3
1	Indurated greensand with shells, and a stratum of oyster shells at water's edge—said to extend 10 feet further down.	10–15

[1] I am indebted to the kindness of Dr. Eugene A. Smith, State Geologist of Alabama, for the use of this heretofore unpublished section.

Bed No. 4 of the preceding section is considered by Dr. Smith to be most closely related in the character of its fossil remains to the fossiliferous strata exposed on Cave and Knight's branches, and it is therefore not unlikely that the series 1–5 corresponds in the main with No. 2 of Tuomey's Bashia section. The basal lignite would then probably be found to underly the lowest stratum exhibited at the Bluff (Heilprin, *loc. cit.*, p. 367–8). Bed No. 6 (Wood's Bluff section) can be traced down the river for a distance of two to three miles, when it dips beneath the water's level. Somewhat below this point, and beyond the mouth of Witch Creek, the stratigraphical relation of the different beds is beautifully exhibited in a prominent cliff ("White Bluff"), rising from 250 to 275 feet above the river. The upper portion of this bluff is constituted by the characteristic siliceous clay-stones and silicified shell deposits of the southern "Buhrstone" formation, which make up fully 100 feet of the vertical height. Laminated lignitic clays (bearing numerous leaf impressions), with occasional intercalated beds of pure lignite, enter mainly into the composition of the intermediate portion, *i. e.*, from the water's level to the base of the buhrstone above mentioned. Allowing a uniform southerly dip of 10 feet to the mile, which appears to be consistent with obtained data, it is manifest that at this point the lower fossiliferous strata exposed at Wood's Bluff (and consequently, the equivalent deposits on Bashia Creek and its tributaries, Cave and Knight's branches) must lie from 175 to 200 feet below the base of the siliceous mass constituting the true buhrstone; or, in other words, we have here a series of deposits aggregating about 300 feet in thickness, which can be shown to be of an age anterior to the depositions of the Claiborne fossiliferous sands. At Baker's Bluff, a few miles above St. Stephen's (which is situated about twenty-eight miles south of Wood's Bluff), the buhrstone, according to Tuomey, appears in a vertical escarpment rising only 50 feet above the water, a low height perfectly in accordance with the loss occasioned by the general dip extending over nearly twenty miles. At this point, moreover, and occupying a position above the buhrstone, Tuomey (*loc. cit.*, p. 148) identifies a bed of green sand (8 feet in thickness) as the equivalent of the Claiborne fossiliferous sands "*d*" of his section), and containing numerous fossils identical with those found at Claiborne. Still further south, and occupying a considerably lower level, the same bed is described

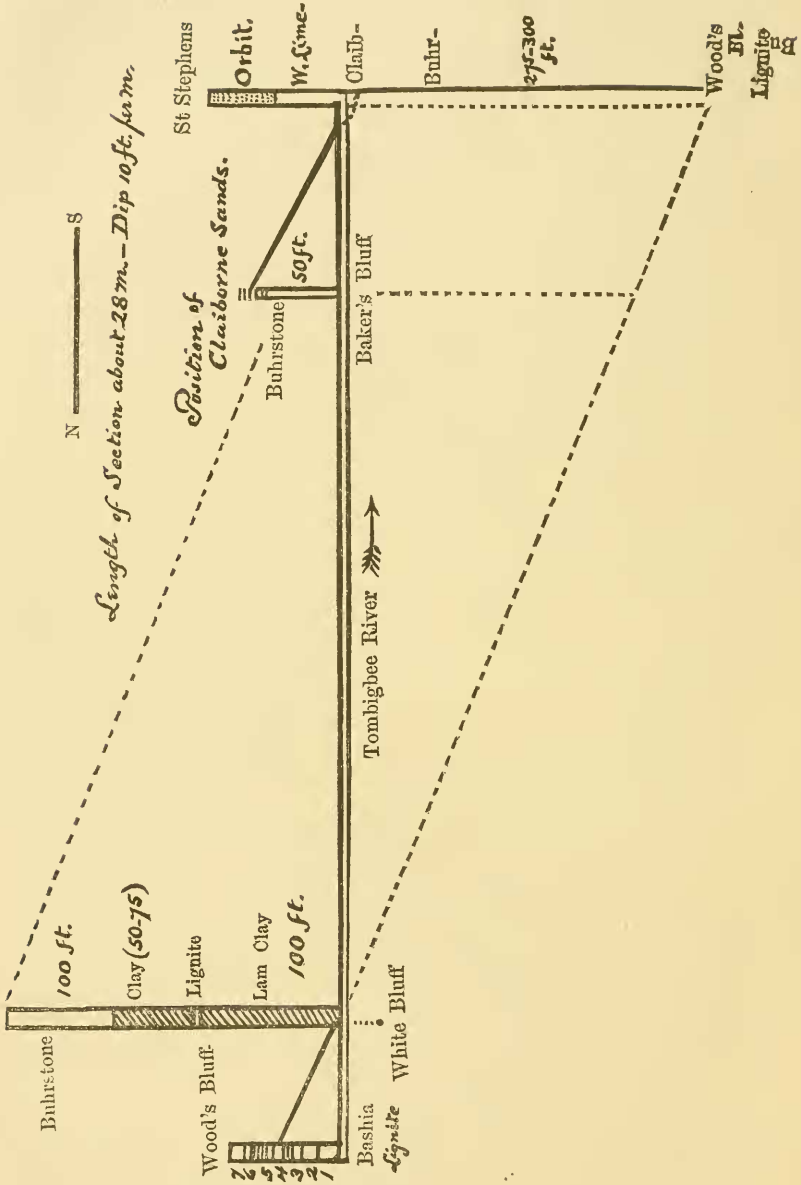
as having an extent of 12 feet, and immediately above St. Stephen's, was seen to dip beneath the water's edge. At this last locality we have a beautiful exhibit of what has generally been designated by the name of "White Limestone."[1]

There can be not the least doubt, however, that this "White Limestone," which has most frequently been taken to represent strata of Vicksburg age, is in reality, as has been insisted upon by Winchell (Proceedings of the American Association, 1856, Part II, p. 85), a combination of strata belonging to two distinct (at least, as now recognized) groups of deposits. The lower moiety, dipping into the river, and resting upon the subjacent Claiborne sands (Tuomey, *loc. cit.*, p. 157; Lyell, Journal Geol. Soc., London, IV, p. 15; Hale, A. J. Science, new ser., VI, p. 359), is the true "White Limestone," an exponent of the Jacksonian group of deposits, as may be inferred from its position, and the character of its contained fossils.[2] Moreover, were it otherwise the case, it would have been very difficult to explain the total disappearance over a distance of only thirty miles (and with but exceedingly moderate dip) of the equivalent beds exposed on the Alabama River at Claiborne. The upper moiety, on the other hand, is a portion of the well known Orbitoide (Vicksburg or Oligocene) rock, and is that which alone contains specimens of *Orbitoides Mantelli* (Winchell, *loc. cit.*, p. 85).

From the data herewith presented, a section of the Tertiary strata traced along the Tombigbee River from Wood's Bluff to St. Stephen's, may probably, with considerable approach to truth, be constructed as follows:

[1] I have been unable to discover the exact height of this bluff. Neither Lyell nor Toumey mentions it; Conrad, in the appendix to Morton's "Synopsis" (p. 23), states it is about 100 feet.

[2] *Spondylus dumosus* and *Ostrea panda*, originally described as characteristic fossils of the Newer Cretaceous (upper Eocene) deposits of the southern United States, have been found abundantly near the base of the bluff.


Length of Section about 28 m. – Dip 10 ft. to m.
N
S
Position of Claiborne Sands.
St Stephens
Orbit.
W. Lime-
Claib-
Buhr-
275-300 ft.
Wood's Bl. Lignite
Buhrstone
50 ft.
Buhrstone
Baker's Bluff
Tombigbee River
100 ft.
Clay (50-75)
Lignite
Lam Clay
100 ft.
Wood's Bluff
Bashia Lignite
White Bluff
7
6
5
4
3
2
1

An examination of the foregoing section shows almost conclusively that the Eocene deposits of Alabama have a thickness of very nearly 400 feet; and, indeed, I am informed by Dr. Smith that there are good grounds for supposing that Tertiary beds exist in the northern part of the State, whose position would be still 150–180 feet below the Wood's Bluff marl bed. It will further be seen that the Claibornian (or Claiborne proper, as characterized by the fossiliferous greensands) holds a position decidedly near the top of the series, a position almost precisely similar to that occupied by the "Calcaire Grossier" (Parisian) of France, and more properly Upper than Middle Eocene, which last it has very generally been considered. What relation beds "b" and "c" of the Claiborne Bluff holds to the sub-Claibornian ("Buhrstone" in part) deposits of the Tombigbee River has not yet been absolutely determined; but there can probably be no legitimate doubts that they represent, in a modified form, the upper moiety of those deposits. Although the marked difference in the lithological character of the strata of the two localities as compared with each other (and indeed it must be confessed, this is much greater than could have been reasonably inferred from the general constancy of the deposits in this region) would seem to militate against such a view, there is, nevertheless, sufficient evidence, both stratigraphical and paleontological, to support this conclusion. In the first place, by determining the position of the buhrstone rock near St. Stephen's as immediately underlying the highly fossiliferous greensand layer, Tuomey has proved that the two series of deposits (the Buhrstone on the Tombigbee, and bed "*c*" on the Alabama) hold relatively the same position to the true Claibornian, lying immediately below it. In the second place, the argillaceous strata at the base of Claiborne Bluff (bed "4" of Hale's series) have been identified by Hale, both on lithological and paleontological evidence (A. J. Science, new ser., VI, p. 356), as occurring at Coffeeville Landing on the Tombigbee River, about 14 miles north of St. Stephen's, what might very readily have been expected from an inspection of the general lay of the different formations.[1] No data are given relative to

[1] A line uniting Claiborne and Coffeeville Landing would run almost precisely parallel with the line marking the junction of the Cretaceous and Tertiary deposits lying hence due north. The contour lines traced by Tuomey would indicate a *true* dip west of the southerly line, and that this

the position of the Buhrstone at this last locality, but hypothetically considered (as deduced from its position at White Bluff, and its general dip), its summit must still occupy a position fully 100 feet above the level of the river; and this thickness (100 feet) coincides very closely with the thickness (80 to 90 feet) of the deposits below the true Claibornian (bed "d") as exposed at the bluff on Alabama River. And finally, that at least a very considerable portion of the inferior beds at this last named locality represent strata of a different lithological character in other portions of the state—and consequently, that they are local deposits—is proved by the concurrent statements of Hale (*loc. cit.*, p. 356) and Winchell (*loc. cit.*, p. 86), both of whom assert that the calcareous deposit below the arenaceous bed (not the "White Limestone") is not known to occur at any other locality.[1]

Admitting the conclusions reached in this paper, it will be seen that the Alabama Eocene deposits comprise:—

4. "White Limestone" (Jacksonian), best exhibited at Claiborne (upper portion of bluff) and St. Stephen's (lower moiety of bluff), not very abundant in fossils—*Pecten membranosus*, *P. Poulsoni*, *Ostrea panda*, *Spondylus dumosus*, "*Scutella*" *Lyelli*, etc.—50 — ? feet.

3. The fossiliferous arenaceous deposit (Claibornian), best shown at Claiborne—subaqueous at St. Stephen's—very rich in fossils, and of the age of the "Calcaire Grossier" of France —17 feet.

2. "Buhrstone" (Siliceous Claiborne of Hilgard), comprising siliceous clay-stones (buhrstone proper) densely charged with fossils or their impressions, laminated clays, sands and calcareous deposits—beds "*b*" and "*c*" of the Claiborne section, the cliff at White Bluff, and the so-called "Chalk

is actually the case is proved by the difference (80–90 feet) between the actual heights at which the equivalent beds at St. Stephen's and Claiborne are placed. This also accords with Hilgard's observations in Mississippi, where the dip of the Jackson and Vicksburg strata was found to be about 10 to 12 feet per mile S. by W. (A. J. Science, new ser., XLIII, p. 36).

[1] It is greatly to be hoped that under the present able management of Dr. Smith, the survey will be able to yield much more satisfactory data connected with the geology of the State than have heretofore been rendered.

Hills" of the southern part of the State. At Claiborne the representative beds consist of aluminous and calcareous deposits, poor in fossils, but containing occasional layers of *Ostrea sellæformis*—about 250 feet?

1. The Wood's Bluff and Bashia (with Cave and Knight's Branches) deposits (Eo-lignitic), consisting of alternating dark clays, greenish and buff sands, and numerous seams of lignite, partly very rich in fossils, and as far as is yet *positively* known, the oldest Tertiary deposits of the State.—50 — ? feet.[1]

It is the intention of the writer to discuss in a future paper the relations of these various Alabama deposits to those of other sections of the United States, and to correlate them, as far as possible, with the Eocene deposits of the typical European basins.

[1] It appears to the author that it would be convenient to designate these lower deposits, which hold a rather constant position at the base of the Eocene series in different parts of the eastern and southern United States, by a term which could be readily applied in adjective form, and which would at the same time in some manner express the relation of the beds referred to. He therefore proposes the term "Eo-lignitic," which, while it to some extent indicates the general character of the beds so designated, is not restricted in its definition to the character of the deposits of any one single locality. The "Buff Sand" of Winchell (*loc. cit.*, p. 89), probably falls into this group, but its exact position, or its correspondent, does not appear to be as yet definitely determined. It is seen to underly the "Buhrstone," and is considered by Winchell to represent the absolute base of the Tertiary system of the State. At Black's Bluff, Wilcox Co., it is stated to repose directly on the subjacent Cretaceous limestone, but in a foot-note (p. 90), we are informed that, according to Tuomey, the characteristic fossil of this limestone, an *Ostrea*, is probably Tertiary.